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STUDY OF THE IMPACT OF STAGGERED WORK HOURS ON PUBLIC TRANSPORTATION COSTS AND SERVICE LEVELS:

PHASE I

CHICAGO TRANSIT AUTHORITY
by

Marda Zimring

TR-75-05

Technical Report

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Planning and Development Department
Regional Transportation Authority
(Northeastern Illinois)
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Chicago, Illinois 60610

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PREFACE

This paper is the initial phase of a three-part study. Phase II will examine the impact of staggered work hours on the commuter railroads and Phase III will examine the feasibility of implementing staggered work hours among the large employers in Chicago's central business district.

ABSTRACT

The "Study of the Impact of Staggered Work Hours on Public Transportation Costs and Service Levels: Phase I Chicago Transit Authority" demonstrates the large positive impacts of staggered work hours on CTA operating and capital costs and on service levels. Various staggered work hour programs were evaluated for bus and rapid transit service using high, medium, low degrees of staggering and three measures of passengers per vehicle.

INTRODUCTION

Rush hour journeys to work concentrate traffic in time, route and direction, causing a problem of considerable dimension in urban mass transportation. This inefficient use of existing transit facilities necessitates gearing an entire system to handle peak loadings which last for two 45-minute periods each workday. During these periods the Chicago Transit Authority carries the highest volume of passengers under the lowest level of personal comfort (Figures I and II). Costs incurred for operating personnel and equipment are determined principally by these peak hour requirements.

Implementation of staggered work hours is advocated as a means of alleviating this problem through transit efficiency. There exists on the CTA system within an hour on either side of the 45-minute peak period, unused transit capacity adequate to accommodate a sufficient portion of the peak 45-minute traffic to produce a significant improvement in transit conditions. Staggered work hours would spread peak demand over a longer time span, reducing operating costs and equipment requirements and/or allowing a higher level of service based on decreased loadings.

Decreased bus and rapid transit loadings, in addition to providing a higher level of service on a general basis, would create a surplus capacity which could be used in the event of gasoline shortages or air pollution episodes. Although increased use of mass transportation has been suggested as a contingency plan in the event of either occurrence, the CTA at the present has no excess capacity in the peak periods to accommodate increases in ridership.

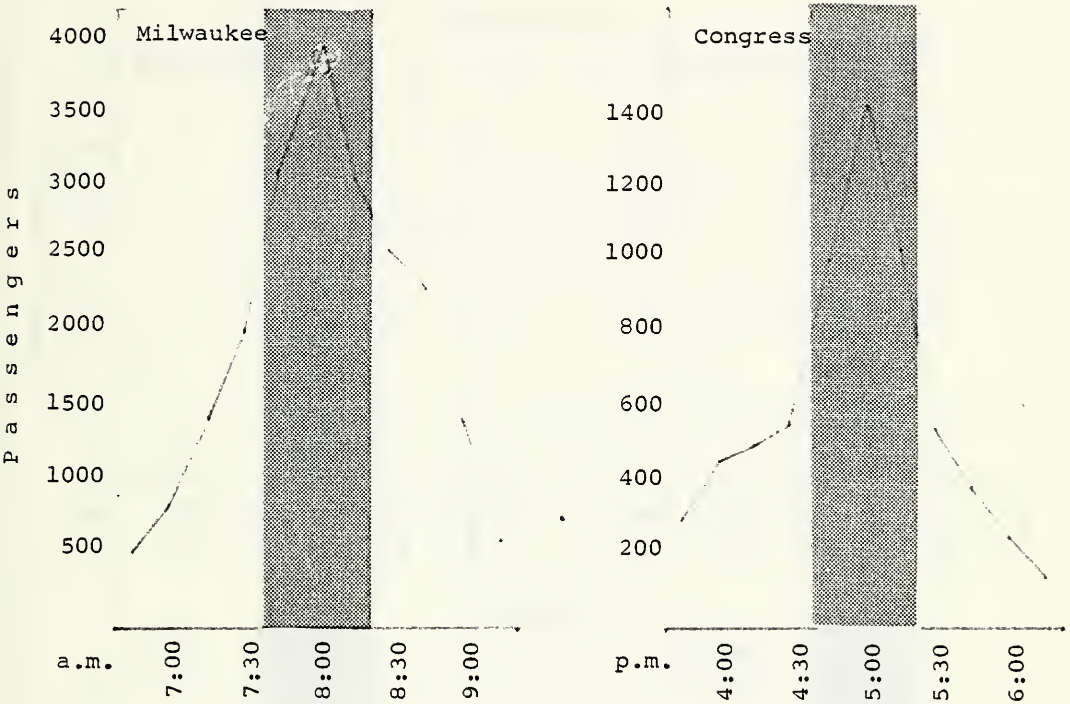
This analysis is a departure from previous staggered work hours studies in that it is strictly from the perspective of the transit operating agency. It does not include any benefits or disadvantages associated with staggered work hours beyond those affecting the CTA's costs and capacity. It was felt that the social impacts of staggered work hours have been proved overwhelmingly positive, as is documented in studies of staggering programs in lower Manhattan, Ottawa, Toronto and Philadelphia.

The issue of modal shift is not felt to be a necessary consideration in this analysis. Although automobile trips would also be staggered, an increase in that mode of travel to work is constrained by parking space, costs, and the fact that trips destined to the central business district represent a smaller proportion of Chicago's expressway traffic.

FIGURE I

Examples of Existing Ridership at
~~Maximum~~ Load Points in Rush Periods

Rapid Transit



Bus

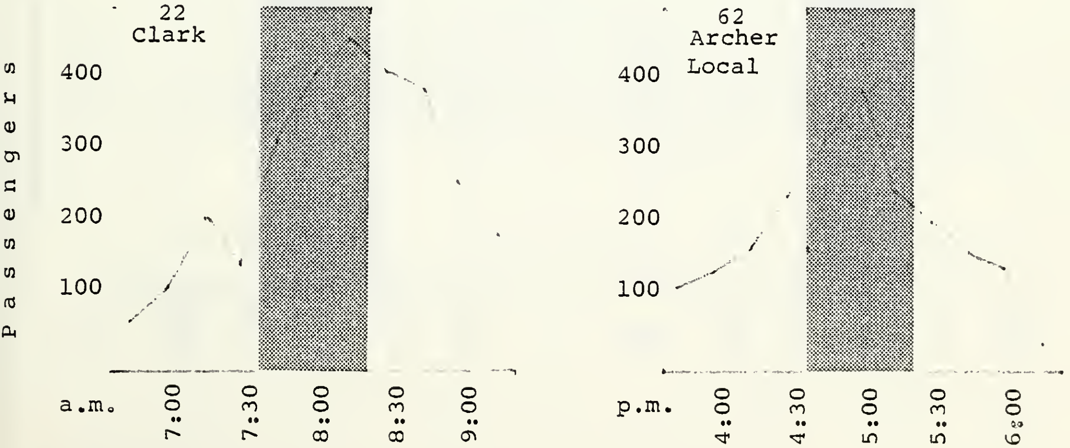
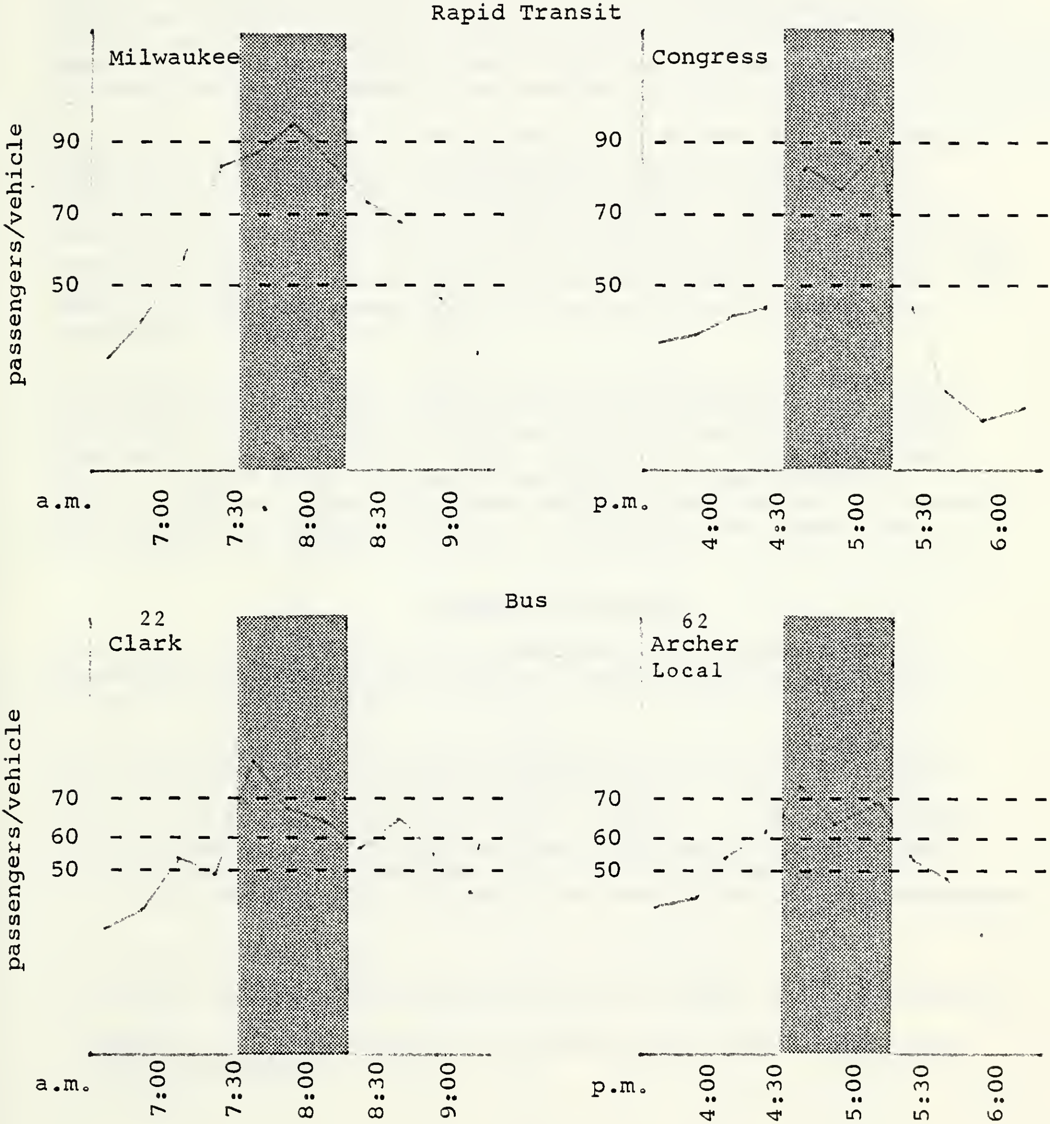


FIGURE II

Examples of Existing Loading at
Maximum Load Points in Rush Periods



SCOPE

Geographical Area

Approximately 40 percent of the work trips to Chicago's Central Business District (CBD), the area bounded by Lake Michigan on the east, Roosevelt Road on the south, Desplaines Avenue and the Chicago River on the west, and a line following Chicago, State and Oak Streets on the north (Figure III) are made by CTA bus and rapid transit.[1] This area has the highest employment density of any area in the region and, subsequently, the greatest degree of crowding and congestion in the region.

An earlier study categorized types of firms according to their ability to incorporate a staggered work hours program.[2] Free firms, the ones most apt to respond favorably to staggered work hours, are not bound by customer flows or external factors. Federal, state and local government offices, insurance companies, corporate offices and other administrative organizations fall within this category. These types of businesses make up a large proportion of CBD employment and are generally not bound by the constraints of union contracts.

The trade-oriented firms are those that adjust their hours to customer flows. These include retailers, wholesale and transit companies. Trade-oriented businesses in Chicago's CBD already open and close at non-peak hours, notably the large department stores. Fixed firms include those tied to a home office or stock brokerage houses which must adjust their houses to industry requirements or external factors. These are the least likely to stagger work hours.

Loading Standards

Three levels of loading, i.e. passengers per vehicle, were selected to represent the range of loading applicable to CTA during the peak periods.

For rapid transit, loadings of 90, 70 and 50 passengers per car were calculated. Ninety passengers per car is the current maximum load scheduled on CTA rapid transit. This is not to say that it has been achieved on all lines or is never exceeded on lines where it generally has been achieved. The other end of the range is 50 passengers per car, an optimum load which provides a seat for every rider. The middle case of 70 passengers

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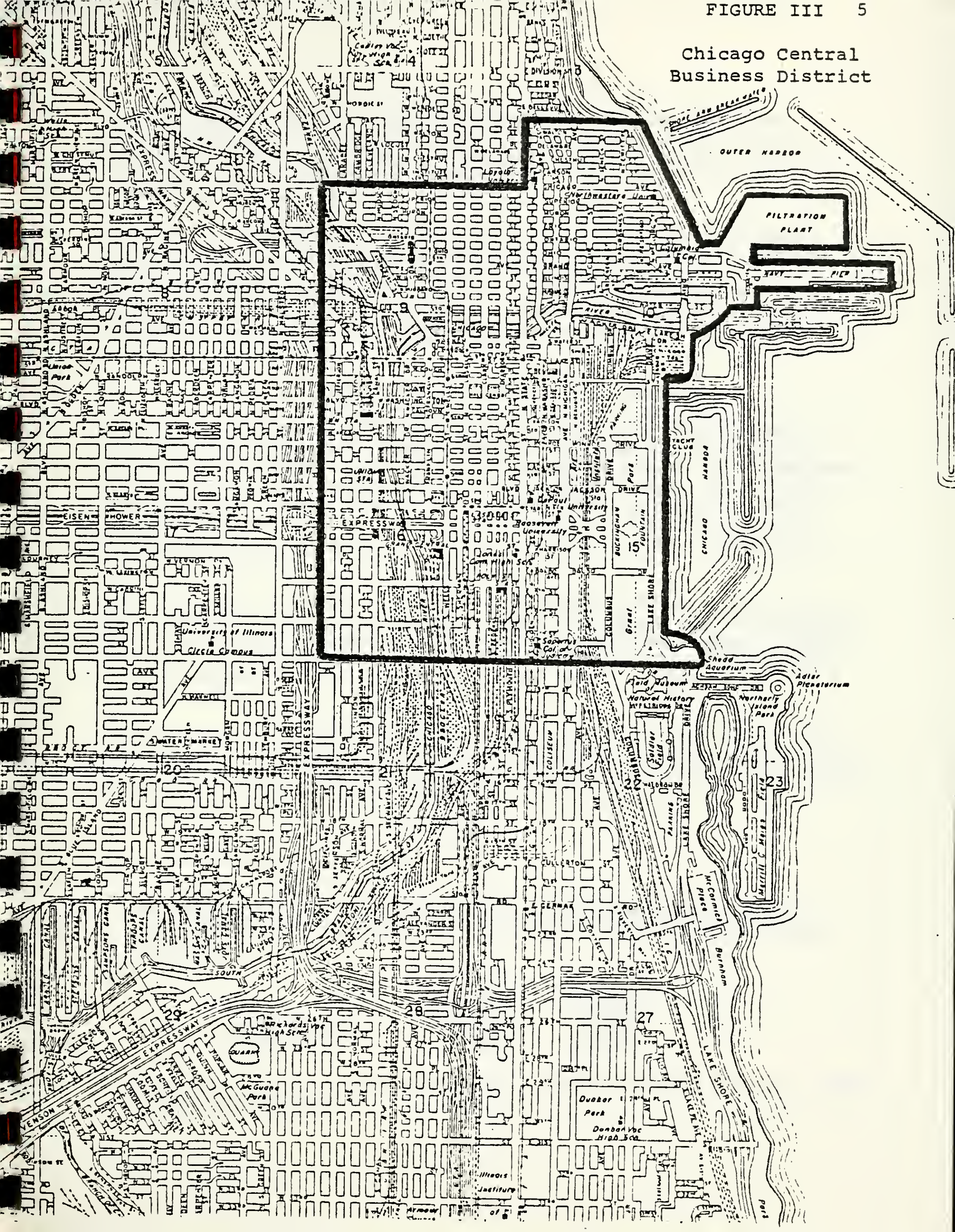
1 Chicago Area Transportation Study, 1970 Home Interview Survey.

2 Gerald L. Drake, "Atlanta's Staggered Work Plan", <u>Municipal South</u> (November, 1972).

Chicago Central Business District



per car was selected to represent what is considered to be both a desirable and potentially feasible system-wide loading standard. It would allow for better passenger comfort, convenience and circulation, and provide excess capacity for emergency situations.

For buses, loadings of 70, 60 and 50 passengers per bus were calculated. Seventy passengers per bus is the current maximum load scheduled on CTA bus lines. As with rapid transit, this level has been achieved in general. Buses typically have 50 seats which sets the lower limit. The 60 passengers per bus standard is considered a desirable and potentially feasible system-wide loading.

Percentage of Passengers Staggered

In order to determine a range of impacts on the CTA, three staggering assumptions were studied. Shifting five percent of the 45-minute peak passengers from the peak period was considered to be the smallest shift which would affect transit costs and operations. Twenty percent was considered the greatest shift which could be implemented, while 10 percent represented the middle case. A no staggering (zero percent shift) alternative was also studied.

The 5, 10 and 20 percent shifts were translated to numbers of CBD employees to be staggered in order to assess the feasibility of a staggering program in terms of total CBD employment. There are 57,556 CBD destined work trips by CTA during the peak 45-minute period[1]: 5% = 2,878 trips, 10% = 5,756 trips, and 20% = 11,511 trips.

Because CTA work trips represent only 44% of all CBD work trips, the following number of work trips (employees) would have to be shifted to affect the corresponding staggering on CTA: 5% = 6,541 trips, 10% = 13,082 trips, and 20% = 26,161 trips.

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1 The number of CBD destined work trips within the 45-minute peak period were totaled for all bus and rapid transit lines studied:

	a.m.	p.m.
Bus	20,369	18,520
Rapid Transit	37,187	37,445
TOTAL	57,556	55,965

The a.m. total was selected as it represented the greater impact on CBD work trips.

There are 366,920 work trips (employees) in the CBD.[1] The staggering of fewer than approximately 26,000 employees is feasible in terms of both numbers and type of CBD employers.

Temporal Parameters

There are two 45-minute periods of extreme peaking in the a.m. and p.m. rush hours. The decision to stagger riders to an hour on each side of the peak 45-minute period was based on an earlier study conducted by the CTA Operations Planning Department.[2] In this study, three alternative staggering patterns were evaluated: (1) two hours before the peak period, (2) two hours after the peak period, and (3) an hour on each side of the peak period. It was the third case which yielded the maximum cost savings.

The decision to use this staggering pattern was supported by the finding of attitudinal studies in other cities which showed that the acceptance of staggered hours diminished as work hours were shifted further away in either direction from the current work schedules.

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1 Chicago Area Transportation Study, 1970 Home Interview Survey.

2 "Cost Savings from CBD Staggered Work Hours," OP-x74469, 1974.

Cost Criteria

All cost savings and expenditures were based on the addition or deletion of vehicle trips. These costs vary under the combinations of loading standards and percentage shifts described above. The addition or deletion of vehicle trips is referred to as the "difference in number of vehicle trips required" in the following discussion. The application of costs is described in the following section.

METHODOLOGY

The methodology involved three primary phases: (1) data collection and modification, the process of translating CTA scheduling data into the form necessary for use in the study; (2) calculations, the process of applying percentages of passengers shifted under various loading standards in order to arrive at the difference in the number of vehicles needed; and (3) analysis, the process of translating the differences in vehicles into operating and capital costs and benefits.

Data Collection and Modification

Included in the study were all rapid transit lines (Except Skokie Swift and Loop Shuttle):

Congress	Evanston	Lake
Dan Ryan	Howard	Milwaukee
Douglas	Jackson Park-Englewood	Ravenswood

and all bus lines entering or operating within the CBD:

62	Archer	16	Lake
62A	Archer Express	11	Lincoln
62X	Archer Expressway	20	Madison
45	Ashland-Downtown	56	Milwaukee
60	Blue Island-26th	120	Northwestern-Wacker Express
36	Broadway	58	Ogden-Downtown
15	Canal-Wacker	128	Orleans
66	Chicago	37	Sedgwick
22	Clark	151	Sheridan (Local/ODX/SRX)
4	Cottage Grove	36A	State
1	Drexel-Hyde Park	149	Stateliner
41	Elston	157	Streeterville
65	Grand	121	Union-Wacker Express
42	Halsted	44	Wallace-Racine

7	Harrison	131	Washington Express
2A	Hyde Park Express	125	Water Tower Express
38	Indiana	22A	Wentworth
126	Jackson	156	Wilson-LaSalle (Local/ WLX/SLX)
5A	Jeffery Express		
3	King Drive	153	Wilson-Michigan (Local/WMX/ODX)

The number of vehicles, passengers, and passengers per vehicle was recorded by 15-minute periods during the 6:45 to 9:30 morning rush and the 3:30 to 6:15 evening rush.[1] Two 45-minute peak periods, 7:45 to 8:30 a.m. and 4:30 to 5:15 p.m., were isolated as the times of predominant CBD-oriented demand, and the passengers in the three 15-minute periods were totaled to obtain the number of 45-minute peak passengers.

Table I is an example of the form used to record data. The scheduling data gave the time at which a vehicle left its terminal and the number of passengers, vehicles and passengers per vehicle at its maximum load point.[2] The maximum load point data was recorded as given; but by using scheduled running times, the time at which the vehicle crossed CBD cordon was substituted for the time it left the terminal. This time modification focused on the crucial issue, the time period in which transit riders enter the CBD in the morning and leave the CBD in the evening.

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1 The CTA 1975 Spring Traffic Check Summaries were the basic data source. In cases where checks were taken on two days, the heavier ridership was used unless delays or other schedule disruptions occurred.

2 The maximum load point for any transit route is the location at which the vehicle carries the greatest number of passengers.

TABLE I

Form for Recording CTA
Maximum Load Point Data

Route ______________________
Maximum Load Point ______________________
Total Number of 45-Minute Peak Passengers _____________

15 Minute Period a.m.	6:45 to 7:00	7:00 to 7:15	7:15 to 7:30	7:30 to 7:45	7:45 to 8:00	8:00 to 8:15	8:15 to 8:30	8:30 to 8:45	8:45 to 9:00	9:00 to 9:15	9:15 to 9:30
# of Passengers											
# of Buses											
Passengers Per Bus											

The maximum load point numbers were used as the base from which to stagger riders. This precluded the possibility of overloading vehicles outside the CBD by basing loads strictly on their CBD ridership. However, not all passengers at the maximum load point reach the CBD, and of those entering the CBD, a percentage are through-riders. The transit riders with work trip destinations in the CBD are the only ones who would be affected by a staggered work hours program. To arrive at the number of riders on each line whose work hours could be staggered, the following inputs and modifications were made:

CASE A: Maximum load point at edge of CBD.

1) Calculated the number of peak riders with CBD destinations by applying the a.m. destined and p.m. originating percentages for bus and rapid transit discussed below.

CASE B: Maximum load point at a short distance from CBD (generally less than 1/2 mile).

1) Estimated for each line, based on field observation, the percentage of riders at the maximum load point who enter the CBD.[1]

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1 CTA Development Planning Department

2) Calculated the number of riders reaching the CBD by applying this percentage.

3) Calculated the number of these riders with CBD destinations by applying the a.m. destined with p.m. originating percentage for bus and rapid transit discussed below.

CASE C: Maximum load point at some distance from CBD, (generally greater than 1/2 mile).

1) Determined the peak 45-minute ridership at either (a) the point at which the vehicle crossed the Cordon Count line[1] or (b) a CTA checkpoint near the CBD to obtain the number of riders reaching the CBD.

2) Calculated the number of these riders with CBD destinations by applying the a.m. destined and p.m. originating percentages for bus and rapid transit discussed below.

Of the total ridership entering the CBD in the a.m. rush period CBD-destined ridership is 77% for rapid transit and 82% for bus. CBD p.m. originating ridership is 70% for rapid transit and 75% for bus. These figures are based on the following calculations:

All CBD 6:45-9:30 a.m. inbound riders on all rapid transit lines (122,251), minus all CBD 6:45-9:30 a.m. outbound riders on all rapid transit lines (27,818), equals the number of CBD destined riders (94,433), which is 77% of all riders entering the CBD.[2] This is the a.m. rapid transit system-wide percentage.[3]

All CBD 3:30-6:15 p.m. outbound riders on all rapid transit lines (122,771), minus all CBD 3:30-6:15 p.m. inbound riders

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[1] 1975 Cordon Count

[2] Based on CTA Bus and Rapid Transit Operating Facts, 16 Hour Checks and Cordon Count data, and the assumption that there are no CBD transit origins in the a.m.

[3] These figures correspond with the 1970 CATS Home Interview Survey results which show a system-wide, all-day figure of 74% CBD destined ridership for all rapid transit riders who enter the CBD.

on all rapid transit lines (36,686), equals the number of originating riders (86,085), which is 70% of all riders leaving the CBD. This is a system-wide p.m. rapid transit percentage.

The a.m. and p.m. percentages of CBD destined and originating bus riders were arrived at by increasing the rapid transit destined and originating percentages by five percent.[1]

Calculations

All calculations were made in order to determine the number of vehicles and vehicle-trips which could be eliminated or would need to be added as the result of staggered work hours. Transit riders with CBD work trip destinations were moved from the peak 45-minute period in the a.m. and p.m. and distributed evenly among the four 15-minute non-peak periods before and four 15-minute non-peak periods after the peak. For both bus and rapid transit 20, 10, and 5 percent shifts of these riders were calculated as illustrated in Table II.

Once the number of passengers per 15-minute period for each of three cases of staggering was calculated for each line in the a.m. and p.m., loading standards were applied to arrive at the number of vehicle-trips which would be necessary.

The loading standards applied to rapid transit were 90, 70 and 50 passengers per car; the loading standards applied to buses were 70, 60 and 50 passengers per bus. The number of passengers per period as calculated above was divided by these standards as illustrated in Table III. At this point the zero percent staggering alternative was introduced for each loading standard to determine the costs of achieving the standards without the implementation of staggered work hours. The case of 90 passengers per rapid transit car and 70 passengers per bus without staggering were the "do nothing", i.e. existing, alternatives.

In applying the loading standards, the number of vehicles was never reduced outside the peak 45-minute period. This was done because only the effects of staggering were desired, and, as passengers were being added to the non-peak periods, any elimi-

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1 Although there is no available data to support this, CTA planning staff considered this to be a conservative estimate.

TABLE II

Form for Calculating Passengers per Period
after Shifts are Implemented

Route ______________________________
Number of Peak 45-Minute Passengers
with CBD Work Trip Destinations ____________________

Time Period a.m.	6:45 to 7:00	7:00 to 7:15	7:15 to 7:30	7:30 to 7:45	7:45 to 8:30	8:30 to 8:45	8:45 to 9:00	9:00 to 9:15	9:15 to 9:30
# Passengers at Max Load Point									
# Passengers with 5% Shift									
# Passengers with 10% Shift									
# Passengers with 20% Shift									

nation of service would merely reflect existing scheduling inefficiencies.

For rapid transit, the number of cars was reduced only by train units, so that in all cases only multiples of the number of cars per train running during a 15-minute period were added or eliminated (4-, 6-, 8-car trains). Due to this constraint, loads were allowed to approach 94, 74, and 54 when addition of an eight- or six-car train would create excessive capacity.

TABLE III

Form for Calculating the Number of Bus Trips Required

Route ______________________

Time Period a.m.		6:45 to 7:00	7:00 to 7:15	7:15 to 7:30	7:30 to 7:45	7:45 to 8:30	8:30 to 8:45	8:45 to 9:00	9:00 to 9:15	9:15 to 9:30
# Buses at Max Load Point										
0% Shift	70 pass/bus									
	60 pass/bus									
	50 pass/bus									
5% Shift	70 pass/bus									
	60 pass/bus									
	50 pass/bus									
10% Shift	70 pass/bus									
	60 pass/bus									
	50 pass/bus									
20% Shift	70 pass/bus									
	60 pass/bus									
	50 pass/bus									

Analysis

A survey of the original data on the work sheets identified lines where further constraints were necessary so as not to overstate the case for staggered work hours. Mere scheduling efficiencies would have been attributed to a staggered hours program without the following constraints:

A. Bus lines #7, #16, #41, #58, #128, and #149 were not given further consideration after the original data gathering as their loads were already extremely low, or they carried predominately local ridership.

B. Bus lines #22A, #36A, #37, #38, #45, #56, #65, and #131 in the a.m., and #3 and #56 in the p.m. had 50 or fewer passengers per bus in all 15-minute periods, or fewer than 50 in all periods except the peak, and an average of fewer than 50 in the peak. Therefore, they were included for further study only for a passenger load of 50.

C. Bus lines #1, #3, #11, #15, #35, #42, #44, #60, #66, #126, and #157 in the a.m., and #22A, #36A, #37, #38, #45, #60, #126, and #157 in the p.m. had heaviest loadings of approximately 60 passengers per bus. Therefore, they were included for further study only for passenger loads of 50 and 60.

D. The Congress, Evanston, Jackson Park/Englewood and Lake rapid transit lines in the a.m., and the Evanston and Lake in the p.m. had heaviest loadings of approximately 70 passengers per car. Therefore, they were included for further study only for passenger loads of 70 and 50.

The calculations of additional vehicles needed outside the peak 45-minute period, and those added or subtracted in the peak period were summarized on forms (Table IV) to show the effects of staggering by line and by time period for each of the nine cases of staggering.

The following data was used to calculate total CTA cost savings or increases for each case of staggering shown in Tables V and VI:

<u>Daily vehicle miles.</u> The total change in the number of bus trips for each line (last column Table IV) was multiplied by the round trip mileage of the route. These figures were then summed for a.m. and p.m. by case of staggering. This was done

TABLE IV

Form for Calculating
the Change in the Number of Bus Trips Required

Route ____________________

Time Period a.m.		6:45 to 7:00	7:00 to 7:15	7:15 to 7:30	7:30 to 7:45	7:45 to 8:30	8:30 to 8:45	8:45 to 9:00	9:00 to 9:15	9:15 to 9:30	Total Δ
70 pass/bus	0% Shift										
	5% Shift										
	10% Shift										
	20% Shift										
60 pass/bus	0% Shift										
	5% Shift										
	10% Shift										
	20% Shift										
50 pass/bus	0% Shift										
	5% Shift										
	10% Shift										
	20% Shift										

TABLE V

CTA Cost Change for CBD Bus Lines

Passengers/Bus Percent Shift	70 0	70 5	70 10	70 20	60 0	60 5	60 10	60 20	50 0	50 5	50 10	50 20
A.M. Δ Bus-Miles P.M. Δ Bus-Miles Daily Δ Bus-Miles	Do nothing alternative	- 541 - 590 - 1,131	- 691 - 800 - 1,493	- 990 - 1,071 - 2,061	+ 566 + 1,066 + 1,632	+ 360 + 815 + 1,175	+ 178 + 671 + 849	- 100 + 355 + 255	+ 2,829 + 3,453 + 6,282	+ 2,807 + 3,224 + 6,031	+ 2,718 + 3,268 + 5,986	+ 2,419 + 2,904 + 5,323
Daily Δ Bus-Mile Cost ($)		- 640	- 845	- 1,167	+ 924	+ 665	+ 481	+ 144	+ 3,555	+ 3,414	+ 3,308	+ 3,013
Annual Δ Bus-Miles Cost ($)		-163,237	- 215,485	297,464	+ 235,547	+ 169,588	+ 122,536	+ 36,804	+ 906,681	+ 870,454	+ 863,959	+ 768,269
Daily Δ Bus Drivers		- 13	- 23	- 36	+ 54	+ 44	+ 38	+ 9	+ 191	+ 168	+ 158	+ 141
Daily Δ Payroll ($)		- 990	- 1,252	- 2,742	+ 4,113	+ 3,351	+ 2,894	+ 605	+ 14,546	+ 12,795	+ 12,033	+ 10,739
Annual Δ Payroll ($)		-252,470	- 446,678	- 699,148	+1,048,723	+ 854,515	+ 737,990	+174,787	+ 3,709,373	+ 3,262,694	+ 3,068,486	+ 2,738,333
Annual Δ Bus Operating Costs ($)		-415,708	- 662,163	- 996,613	+1,284,270	+1,024,103	+ 860,527	+211,591	+ 4,616,054	+ 4,133,148	+ 3,932,446	+ 3,506,606
Δ Buses Required		- 13	- 23	- 36	+ 54	+ 44	+ 38	+ 9	+ 191	+ 168	+ 158	+ 141
Marginal Capital Cost Δ ($)		-975,000	-1,725,000	-2,700,000	+4,050,000	+3,300,000	+2,850,000	+675,000	+14,325,000	+12,600,000	+11,850,000	+10,575,000
Annual Δ Marginal Capital Costs ($)		- 81,250	- 143,750	- 225,000	+ 337,500	+ 275,000	+ 237,500	+ 56,250	+ 1,193,750	+ 1,050,000	+ 987,500	+ 881,250

TABLE VI

CTA Cost Change for Rapid Transit

Passengers/Car Percent Shift	90 0	90 5	90 10	90 20	70 0	70 5	70 10	70 20	50 0	50 5	50 10	50 20
A.M. Δ Car-Miles P.M. Δ Car-Miles Daily Δ Car-Miles	Do nothing alternative	- 2,455 - 2,687 - 5,142	- 3,025 - 3,337 - 6,362	- 3,796 - 4,465 - 8,261	+ 1,470 + 4,790 + 6,260	+ 115 + 3,577 + 3,712	+ 180 + 2,733 + 2,913	+ 7 + 1,531 + 1,538	+ 18,046 + 22,223 + 41,079	+ 10,183 + 21,273 + 39,456	+ 18,267 + 20,597 + 38,864	+ 18,122 + 19,505 + 37,627
Daily Δ Car-Mile Cost ($)		- 2,658	- 3,289	- 4,271	+ 3,236	+ 1,519	+ 1,506	+ 795	+ 21,230	+ 20,399	+ 20,093	+ 19,453
Annual Δ Car-Mile Cost ($)		- 627,895	- 838,734	- 1,089,089	+ 825,287	+ 489,372	+ 384,035	+ 202,262	+ 5,415,650	+ 5,201,682	+ 5,123,635	+ 4,960,556
Daily Δ Motorman/Conductors		- 4	- 5	- 8	+ 19	+ 11	+ 12	+ 5	+ 72	+ 75	+ 79	+ 76
Daily Δ Payroll ($) 1		- 611	- 764	- 1,223	+ 2,904	+ 1,592	+ 1,834	+ 764	+ 11,006	+ 11,465	+ 12,076	+ 11,617
Annual Δ Payroll ($)		- 155,917	- 194,897	- 311,834	+ 740,607	+ 506,731	+ 467,752	+ 194,897	+ 2,806,510	+ 2,923,448	+ 3,079,365	+ 2,962,427
Annual Δ Rapid Transit Operating Cost ($)		- 833,812	- 1,033,631	- 1,400,923	+ 1,565,894	+ 996,103	+ 851,787	+ 397,659	+ 8,222,160	+ 8,125,130	+ 8,203,000	+ 7,922,983
Δ Cars Required		- 28	- 36	- 62	+ 128	+ 38	+ 78	+ 34	+ 570	+ 400	+ 526	+ 390
Marginal Capital Cost Δ ($)		-12,600,000	-16,200,000	-27,900,000	+57,600,000	+39,600,000	+35,100,000	+15,300,000	+256,500,000	+216,000,000	+236,700,000	+179,100,000
Annual Δ Marginal Capital Cost ($)		- 504,000	- 648,000	- 1,116,000	+ 2,304,000	+ 1,584,000	+ 1,404,000	+ 612,000	+ 10,260,000	+ 8,640,000	+ 9,468,000	+ 7,164,000

for all 12 cases of staggering. The same was done for rapid transit.

Cost per vehicle mile. The cost per bus mile used was 56.6¢. This includes maintenance fueling, injuries and damages. The cost per rapid transit car miles was 51.7¢.[1] These costs do not include operator costs.

Daily Vehicle miles. The total change in vehicle miles for each of the 12 cases of staggering was multiplied by the appropriate cost per vehicle mile.

Daily operators. For each line this is the total number of trips, minus the number of repeat trips[2] by the same bus driver or motorman and conductor for the morning or the evening, whichever is greater. After calculation by line, they were summed. This is based on the fact that by union contract an operator must be employed and paid for an entire day.

Daily payroll costs. For buses: (number of runs) x (8.0 pay hours) x ($7.00 per hour) + (36% overhead) = payroll costs per day.

For rapid transit: (number of runs) x (8.0 pay hours) x ($7.00 per conductor hour +$7.05 per motorman hour) + (36% overhead) = payroll costs per day.

Annual operating costs. The daily vehicle mile and operator costs were added and multiplied by 255 days to arrive at the annual operating costs.

Marginal capital costs. For bus lines the marginal capital cost difference equaled the change in the number of buses required, multiplied by the 1975 cost of a CTA bus, $75,000. The change

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1 CTA OP-x75161, "Operating Costs Per Vehicle Mile".

2 The number of repeat trips for bus operators was arrived at by increasing the round trip time of a line by 15% to account for the time a bus spends at the terminal before pulling out for a repeat trip, and then applying this time to the Table IV set of tables to see where the same bus and driver repeated a trip in the study period. The same procedure was used for rapid transit, except that operating personnel do not stay with the same train, and in general, drop back one 15-minute period. This is reflected in the repeat trips by the same operators.

in the number of buses required was equal to the number of drivers required. For rapid transit the calculation method was the same, but the rapid transit car cost of $450,000 was used. The change in the number of cars required was calculated in the same manner as described above for the change in the number of conductors and motormen.

The marginal capital cost figures assume that the current CTA objective of maintaining or reducing the average age of the fleet is operative. It does not account for the cost of yards, garages or other miscellaneous costs associated with either an increased or decreased fleet.

Annual marginal capital costs. Straight line depreciation of 12 years for buses and 25 years for rapid transit cars was used. No salvage value was assumed.[1]

RESULTS

The summary of annual operating and marginal cost differences for bus and rapid transit found in Table VII is based on the data in Tables V and VI. The cost savings or increases are discussed in terms of loading standards, with the percentage shift giving a range of results within the loading standard. The zero percent shift remains the cost of reaching the loading standard with no staggered work hours. The bus loading of 70 with zero percent shift and the rapid transit loading of 90 with zero percent shift represent the "do nothing" alternatives.

70 Passengers per Bus and 90 Passengers per Car

Seventy passengers per bus and 90 passengers per transit car are the existing maximum CTA loading standards to which all scheduling is directed. As shown in Table VII, in all cases of staggering under these loadings there is a cost savings for CTA which increases with increased staggering. For the CBD bus lines the annual cost savings ranges from $500,000 to $1.2 million. For rapid transit the annual cost savings ranges from $1.3 million to $2.5 million. Under a staggered work hours program, which keeps loading standards at their current level, the CTA can save from $1.8 million to $3.7 million annually.

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[1] American Transit Association, Transit Operating Reports, 1974.

TABLE VII

Summary of Annual Operating and Marginal Cost Differences for Bus and Rapid Transit

Passengers Per Vehicle	Percent Shift	Annual Change in Operating Cost($)	Annual Change in Marginal Capital Cost ($)	Annual Change in Capital and Operating Cost($)
Bus				
70	0	Do nothing alternative		
70	5	- 415,708	- 81,250	- 496,958
70	10	- 662,163	- 143,750	- 805,913
70	20	- 996,613	- 225,000	- 1,221,613
60	0	+ 1,284,270	+ 337,500	+ 1,621,770
60	5	+ 1,024,103	+ 275,000	+ 1,299,103
60	10	+ 860,527	+ 237,500	+ 1,098,027
60	20	+ 211,591	+ 56,250	+ 267,841
50	0	+ 4,616,054	+ 1,193,750	+ 5,809,804
50	5	+ 4,133,148	+ 1,050,000	+ 5,183,148
50	10	+ 3,932,446	+ 987,500	+ 4,919,946
50	20	+ 3,506,000	+ 881,250	+ 4,387,250
Rapid Transit				
90	0	Do nothing alternative		
90	5	- 833,812	- 504,000	- 1,337,812
90	10	- 1,033,631	- 648,000	- 1,681,613
90	20	- 1,400,923	- 1,116,000	- 2,516,923
70	0	+ 1,565,894	+ 2,304,000	+ 3,869,894
70	5	+ 996,103	+ 1,584,000	+ 2,580,103
70	10	+ 851,787	+ 1,404,000	+ 2,255,787
70	20	+ 397,659	+ 612,000	+ 1 009,659
50	0	+ 8,222,160	+ 10,260,000	+ 18,482,160
50	5	+ 8,125,130	+ 8,640,000	+ 16,765,130
50	10	+ 8,203,000	+ 9,468,000	+ 17,671,000
50	20	+ 7,922,983	+ 7,164,000	+ 15,086,983

50 Passengers per Bus or Car

The case of 50 passengers per bus or rapid transit car is the optimum loading standard achievable, a seat for every passenger. In all cases this can be achieved only at a substantial cost increase, but one that diminishes with increased staggering. For both bus and rapid transit the cost of 50 passengers per vehicle loading costs less with staggered hours than without.

For rapid transit the achievement of a seat for every passenger is not feasible within the next few years due to constraints beyond the financial ones. According to an earlier study, "The Cost/Benefit of Reducing Rush-Hour Loading,"[1] the availability of additional cars and limited track capacity are both insurmountable obstacles in the short range.

As indicated in Table VI, 50 passengers per transit car would require from 398 to 526 cars depending on the amount of staggering. CTA currently has only 200 cars on order, none of which will be in service until 1977. In addition, the purchase of these cars was based on the necessity of retiring cars which have components nearly 30 years old.

Track capacity is constrained on most routes, especially the Loop elevated where five services converge. According to the study, to significantly reduce loading would require scheduled headways of less than two minutes on most routes. Such headways are not operationally practical for extended periods.

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[1] CTA Development Planning and Operations Planning Departments, October, 1975.

For buses the achievement of seated loads on all CBD routes, even with staggering, would require from 141 to 168 additional buses as indicated in Table V. This is not an infeasible number of buses given sufficient lead time to implement.[1] The annual cost ranges from $4.3 million to $5.1 million depending on the amount of staggering.

60 Passengers per Bus and 70 Passengers per Car

Sixty passengers per bus and 70 passengers per car are standards which best fulfill the joint objectives of staggered work hours, cost saving and improved levels of service. These loadings represent a significant improvement over current loading standards and are achievable at minimal cost (Table VII).

A loading standard of 60 passengers per bus can be achieved at an annual cost ranging from $300,000 to $1.3 million, depending on the amount of staggering, and requires from 9 to 44 buses. The lower end of the cost spectrum, possible with 20 percent staggering, is basically a no-cost option.

A loading standard of 70 passengers per rapid transit car can be achieved at an annual cost ranging from $1.0 million to $2.6 million, depending on the amount of staggering, and requires from 34 to 88 additional cars. The cost associated with a 20 percent shift in ridership is especially reasonable in view of the significant improvement in service, and the increase in cars

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1 The Rush-Hour Loading Study referenced above noted that scheduling seated loads on buses and not rapid transit would be undesirable. This significant departure from current rush-hour standards, with the associated increases in comfort and convenience, would draw public attention. Because the bus loading would be significantly different than that on rapid transit, bus ridership could increase at the expense of rapid transit.

Diverting present rail passengers to bus services through an improved comfort level on the buses would be one way to reduce crowding on rail service. However, it would be undesirable from the standpoint of carrying rush-hour passengers in the most efficient manner. This phenomenon would also make the costs in Table VII only the initial costs, as maintaining 50 passengers per bus would be increasingly expensive as riders continue to be diverted from rail to bus.

and car-miles is practical in terms of track capacity.

RECOMMENDATIONS FOR FURTHER STUDY

The large positive impacts of a staggered work hours program on CTA's operations and costs demonstrated in this study are the basis for CTA's advocacy of such a program in the Chicago CBD. In addition, reduced loading standards would improve circulation on vehicles, especially the buses, improving CTA's image among both riders and non-riders and most likely increasing ridership.

The appropriate next step would be to determine the costs and benefits which would accrue to the other carriers in the area who would be affected by staggered work hours. The commuter rail lines, with one exception, are reluctant to cooperate in a staggered work hours program due to a combination of issues, the most significant of which is potential interference with freight operations over the same tracks. An analysis of the commuter railroads similar to that of CTA would either support or disprove that opinion. Such a study should be done at the Regional Transportation Authority level in cooperation with the railroads.

In the past, the Chicago Association of Commerce and Industry, as the representative of the business community, has supported staggered work hours. This indicates a good climate in which to initiate implementation of staggered work hours should political backing of such a broad scale effort be forthcoming.

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